ANNEX C: Methodology for Estimating Emissions of CH_4, N_2O, and Criteria Pollutants from Mobile Combustion

Estimates of CH_4 and N_2O Emissions

Greenhouse gas emissions from mobile combustion are reported by transport mode (e.g., road, rail, air, and water), vehicle type, and fuel type. The EPA does not systematically track emissions of CH_4 and N_2O as in EPA (1999); therefore, estimates of these gases were developed using a methodology similar to that outlined in the *Revised 1996 IPCC Guidelines* (IPCC/UNEP/OECD/IEA 1997).

Step 1: Determine Vehicle Miles Traveled or Fuel Consumption by Vehicle Type, Fuel Type, and Model Year

Activity data were obtained from a number of U.S. government agency publications. Depending on the category, these basic activity data included such information as fuel consumption, fuel deliveries, and vehicle miles traveled (VMT). The activity data for highway vehicles included estimates of VMT by vehicle type and model year from EPA (1999) and the MOBILE5a emissions model (EPA 1997).

National VMT data for gasoline and diesel highway vehicles are presented in Table C-1 and Table C-2, respectively. Total VMT for each highway category (i.e., gasoline passenger cars, light-duty gasoline trucks, heavy-duty gasoline vehicles, diesel passenger cars, light-duty diesel trucks, heavy-duty diesel vehicles, and motorcycles) were distributed across 25 model years based on the temporally fixed age distribution of VMT by the U.S. vehicle fleet in 1990 (see Table C-3) as specified in MOBILE5a. Activity data for gasoline passenger cars and light-duty trucks in California were developed separately due to the different emission control technologies deployed in that state relative to the rest of the country. Unlike the rest of the United States, beginning in model year 1994, a fraction of the computed California VMT for gasoline passenger cars and light-duty trucks was attributed to low emission vehicles (LEVs). LEVs have not yet been widely deployed in other states. Based upon U.S. Department of Transportation statistics for 1994, it was assumed that 8.7 percent of national VMT occurred in California.

Activity data for non-highway vehicles were based on annual fuel consumption statistics by transportation mode and fuel type. Consumption data for distillate and residual fuel oil by ships and boats (i.e., vessel bunkering), construction equipment, farm equipment, and locomotives were obtained from EIA (1999b). In the case of ships and boats, the EIA (1999b) vessel bunkering data was reduced by the amount of fuel used for international bunkers.[1] Data on the consumption of jet fuel in aircraft were obtained directly from DOT/BTS, as described under CO_2 from Fossil Fuel Combustion, and were reduced by the amount allocated to international bunker fuels. Data on aviation gasoline consumed in aircraft were taken from FAA (1999). Data on the consumption of motor gasoline by ships and boats, construction equipment, farm equipment, and locomotives data were drawn from FHWA (1998). For these vehicles, 1997 fuel consumption data were used as a proxy because 1998 data were unavailable. The activity data used for non-highway vehicles are included in Table C-4.

Step 2: Allocate VMT Data to Control Technology Type for Highway Vehicles

For highway sources, VMT by vehicle type for each model year were distributed across various control technologies as shown in Table C-5, Table C-6, Table C-7, Table C-8, and Table C-9. Again, California gasoline-fueled passenger cars and light-duty trucks were treated separately due to that state's distinct vehicle emission standards—including the introduction of Low Emission Vehicles (LEVs) in 1994—compared with the rest of the United States. The categories "Tier 0" and "Tier 1" were substituted for the early three-way catalyst and advanced three-way catalyst categories, respectively, as defined in the *Revised 1996 IPCC Guidelines*. Tier 0, Tier 1, and LEV are actually U.S. emission regulations, rather than control technologies; however, each does correspond to

[1] See International Bunker Fuels.

particular combinations of control technologies and engine design. Tier 1 and its predecessor Tier 0 both apply to vehicles equipped with three-way catalysts. The introduction of "early three-way catalysts," and "advance three-way catalysts" as described in the *Revised 1996 IPCC Guidelines*, roughly correspond to the introduction of Tier 0 and Tier 1 regulations (EPA 1998).

Step 3: Determine the Amount of CH_4 and N_2O Emitted by Vehicle, Fuel, and Control Technology Type

Emissions of CH_4 and N_2O from non-highway vehicles were calculated by multiplying emission factors in IPCC/UNEP/OECD/IEA (1997) by activity data for each vehicle type as described in Step 1 (see Table C-10 and Table C-11). The CH_4 emission factors for highway sources were derived from the EPA's MOBILE5a mobile source emissions model (EPA 1997). The MOBILE5a model uses information on ambient temperature, diurnal temperature range, altitude, vehicle speeds, national vehicle registration distributions, gasoline volatility, emission control technologies, fuel composition, and the presence or absence of vehicle inspection/maintenance programs in order to produce these factors.

Emissions of N_2O—in contrast to CH_4, CO, NO_x, and NMVOCs—have not been extensively studied and are currently not well characterized. The limited number of studies that have been performed on highway vehicle emissions of N_2O have shown that emissions are generally greater from vehicles with catalytic converter systems than those without such controls, and greater from aged than from new catalysts. These systems control tailpipe emissions of NO_x (i.e., NO and NO_2) by catalytically reducing NO_x to N_2. Suboptimal catalyst performance, caused by as yet poorly understood factors, results in incomplete reduction and the conversion of some NO_x to N_2O rather than to N_2. Fortunately, newer vehicles with catalyst and engine designs meeting the more recent Tier 1 and LEV standards have shown reduced emission rates of both NO_x and N_2O.

In order to better characterize the process by which N_2O is formed by catalytic controls and to develop a more accurate national emission estimate, the EPA's Office of Mobile Sources—at its National Vehicle and Fuel Emissions Laboratory (NVFEL)—conducted a series of tests in order to measure emission rates of N_2O from used Tier 1 and LEV gasoline-fueled passenger cars and light-duty trucks equipped with catalytic converters. These tests and a review of the literature were used to develop the emission factors for N_2O (EPA 1998). The following references were used in developing the N_2O emission factors for gasoline-fueled highway passenger cars presented in Table C-10:

- *LEVs*. Tests performed at NVFEL (EPA 1998)[2]
- *Tier 1*. Tests performed at NVFEL (EPA 1998)
- *Tier 0*. Smith and Carey (1982), Barton and Simpson (1994), and one car tested at NVFEL (EPA 1998)
- *Oxidation Catalyst*. Smith and Carey (1982), Urban and Garbe (1979)
- *Non-Catalyst*. Prigent and de Soete (1989), Dasch (1992), and Urban and Garbe (1979)

Nitrous oxide emission factors for other types of gasoline-fueled vehicles—light-duty trucks, heavy-duty vehicles, and motorcycles—were estimated by adjusting the factors for gasoline passenger cars, as described above, by their relative fuel economies. This adjustment was performed using the carbon dioxide emission rates in the *Revised 1996 IPCC Guidelines* (IPCC/UNEP/OECD/IEA 1997) as a proxy for fuel economy (see Table C-10). Data from the literature and tests performed at NVFEL support the conclusion that light-duty trucks have higher emission rates than passenger cars. However, the use of fuel-consumption ratios to determine emission factors is considered a temporary measure only, to be replaced as soon as real data are available.

[2] It was assumed that LEVs would be operated using low-sulfur fuel (i.e., Indolene at 24 ppm sulfur). All other NVFEL tests were performed using a standard commercial fuel (CAAB at 285 ppm sulfur). Emission tests by NVFEL have consistently exhibited higher N_2O emission rates from higher sulfur fuels on Tier 1 and LEV vehicles.

The resulting N_2O emission factors employed for gasoline highway vehicles are lower than the U.S. default values presented in the *Revised 1996 IPCC Guidelines*, but are higher than the European default values, both of which were published before the more recent tests and literature review conducted by the NVFEL. The U.S. defaults in the *Guidelines* were based on three studies that tested a total of five cars using European rather than U.S. test procedures.

Nitrous oxide emission factors for diesel highway vehicles were taken from the European default values found in the *Revised 1996 IPCC Guidelines* (IPCC/UNEP/OECD/IEA 1997). There is little data addressing N_2O emissions from U.S. diesel-fueled vehicles, and in general, European countries have had more experience with diesel-fueled vehicles. U.S. default values in the *Revised 1996 IPCC Guidelines* were used for non-highway vehicles.

Compared to regulated tailpipe emissions, there is relatively little data available to estimate emission factors for N_2O. Nitrous oxide is not a criteria pollutant, and measurements of it in automobile exhaust have not been routinely collected. Further testing is needed to reduce the uncertainty in nitrous oxide emission factors for all classes of vehicles, using realistic driving regimes, environmental conditions, and fuels.

Estimates of NO_x, CO, and NMVOC Emissions

The emission estimates of NO_x, CO, and NMVOCs for mobile combustion were taken directly from the EPA's *National Air Pollutant Emissions Trends, 1900 - 1998* (EPA 1999). This EPA report provides emission estimates for these gases by sector and fuel type using a "top down" estimating procedure whereby emissions were calculated using basic activity data, such as amount of fuel delivered or miles traveled, as indicators of emissions. Table C-12 through Table C-14 provide complete emissions estimates for 1990 through 1998.

Table C-1: Vehicle Miles Traveled for Gasoline Highway Vehicles (10^9 Miles)

Year	Passenger Cars[a]	Light-Duty Trucks[a]	Heavy-Duty Vehicles	Motorcycles	Passenger Cars (CA)[b]	Light-Duty Trucks (CA)[b]
1990	1,268.19	520.28	42.08	9.64	120.85	49.58
1991	1,223.05	588.03	42.88	9.30	116.54	56.03
1992	1,235.38	640.07	43.66	9.37	117.72	60.99
1993	1,238.52	675.29	46.01	9.37	118.02	64.35
1994	1,266.89	692.39	49.65	9.59	120.72	65.98
1995	1,295.30	715.38	50.79	9.80	123.43	68.17
1996	1,322.82	738.84	51.84	9.91	126.05	70.40
1997	1,336.47	761.00	53.66	9.96	127.35	72.52
1998	1,366.67	778.20	54.87	10.18	130.23	74.15

[a] Excludes California
[b] California VMT for passenger cars and light-duty trucks was treated separately and estimated as 8.7 percent of national total.
Source: VMT data are the same as those used in EPA (1999).

Table C-2: Vehicle Miles Traveled for Diesel Highway Vehicles (10^9 Miles)

Year	Passenger Cars	Light-Duty Trucks	Heavy-Duty Vehicles
1990	19.2	4.7	109.9
1991	18.5	5.3	112.4
1992	18.7	5.8	115.5
1993	18.7	6.1	120.0
1994	19.1	6.3	127.0
1995	19.6	6.5	133.8
1996	20.0	6.7	137.5
1997	20.2	6.8	143.0
1998	20.6	6.9	146.3

Source: VMT data are the same as those used in EPA (1999).

Table C-3: VMT Profile by Vehicle Age (Years) and Vehicle/Fuel Type for Highway Vehicles (Percent of VMT)

Vehicle Age	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
1	4.9%	6.3%	2.3%	4.9%	6.3%	3.4%	14.4%
2	7.9%	8.4%	4.7%	7.9%	8.4%	6.7%	16.8%
3	8.3%	8.4%	4.7%	8.3%	8.4%	6.7%	13.5%
4	8.2%	8.4%	4.7%	8.2%	8.4%	6.7%	10.9%
5	8.4%	8.4%	4.7%	8.4%	8.4%	6.7%	8.8%
6	8.1%	6.9%	3.8%	8.1%	6.9%	7.3%	7.0%
7	7.7%	5.9%	3.3%	7.7%	5.9%	6.1%	5.6%
8	5.6%	4.4%	2.1%	5.6%	4.4%	4.0%	4.5%
9	5.0%	3.6%	2.6%	5.0%	3.6%	4.1%	3.6%
10	5.1%	3.1%	2.9%	5.1%	3.1%	5.1%	2.9%
11	5.0%	3.0%	3.4%	5.0%	3.0%	5.3%	2.3%
12	5.4%	5.3%	6.4%	5.4%	5.3%	6.6%	9.7%
13	4.7%	4.7%	5.4%	4.7%	4.7%	5.5%	0.0%
14	3.7%	4.6%	5.8%	3.7%	4.6%	5.7%	0.0%
15	2.4%	3.6%	5.1%	2.4%	3.6%	4.5%	0.0%
16	1.9%	2.8%	3.8%	1.9%	2.8%	1.9%	0.0%
17	1.4%	1.7%	4.3%	1.4%	1.7%	2.3%	0.0%
18	1.5%	2.2%	4.1%	1.5%	2.2%	2.8%	0.0%
19	1.1%	1.7%	3.5%	1.1%	1.7%	2.4%	0.0%
20	0.8%	1.4%	2.9%	0.8%	1.4%	1.6%	0.0%
21	0.6%	0.9%	2.1%	0.6%	0.9%	1.1%	0.0%
22	0.5%	0.8%	2.2%	0.5%	0.8%	0.9%	0.0%
23	0.4%	0.8%	2.2%	0.4%	0.8%	0.7%	0.0%
24	0.3%	0.5%	1.4%	0.3%	0.5%	0.5%	0.0%
25	1.0%	2.5%	11.7%	1.0%	2.5%	1.6%	0.0%

LDGV (gasoline passenger cars, also referred to as light-duty gas vehicles)
LDGT (light-duty gas trucks)
HDGV (heavy-duty gas vehicles)
LDDV (diesel passenger cars, also referred to as light-duty diesel vehicles)
LDDT (light-duty diesel trucks)
HDDV (heavy-duty diesel vehicles)
MC (motorcycles)

Table C-4: Fuel Consumption for Non-Highway Vehicles by Fuel Type (U.S. Gallons)

Vehicle Type/Year	Residual	Diesel	Jet Fuel	Other
Aircraft[a]				
1990	-	-	17,055,286,001	355,100,000
1991	-	-	16,022,943,658	355,600,000
1992	-	-	16,444,526,173	300,000,000
1993	-	-	16,686,897,872	273,000,000
1994	-	-	17,150,828,119	268,200,000
1995	-	-	17,882,934,898	289,300,000
1996	-	-	18,453,097,849	290,500,000
1997	-	-	19,265,762,116	294,200,000
1998			19,271,920,783	297,800,000
Ships and Boats[b]				
1990	1,165,580,227	1,829,927,570	-	1,300,400,000
1991	1,486,167,178	1,806,653,451	-	1,709,700,000
1992	2,347,064,583	1,820,275,621	-	1,316,170,000
1993	2,758,924,466	1,661,285,902	-	873,687,000
1994	2,499,868,472	1,746,597,258	-	896,700,000
1995	2,994,692,916	1,636,189,216	-	1,060,394,000
1996	2,280,373,162	1,952,357,254	-	993,671,000

1997	1,005,997,126	1,917,777,070	-	993,671,000
1998	666,587,222	1,498,285,988		993,671,000
Construction Equipment[c]				
1990	-	2,508,300,000	-	1,523,600,000
1991	-	2,447,400,000	-	1,384,900,000
1992	-	2,287,642,000	-	1,492,200,000
1993	-	2,323,183,000	-	1,270,386,667
1994	-	2,437,142,000	-	1,312,161,667
1995	-	2,273,162,000	-	1,351,642,667
1996	-	2,386,973,000	-	1,365,550,667
1997	-	2,385,236,000	-	1,365,550,667
1998	-	2,432,182,000		1,365,550,667
Farm Equipment[d]				
1990	-	3,164,200,000	-	812,800,000
1991	-	3,144,200,000	-	776,200,000
1992	-	3,274,811,000	-	805,500,000
1993	-	3,077,122,000	-	845,320,000
1994	-	3,062,436,000	-	911,996,000
1995	-	3,093,224,000	-	926,732,000
1996	-	3,225,029,000	-	918,085,000
1997	-	3,206,359,000	-	918,085,000
1998	-	2,965,006,000	-	918,085,000
Locomotives				
1990	25,422	3,210,111,000	-	-
1991	6,845	3,026,292,000	-	-
1992	8,343	3,217,231,000	-	-
1993	4,065	2,906,998,000	-	-
1994	5,956	3,063,441,000	-	-
1995	6,498	3,191,023,000	-	-
1996	9,309	3,266,861,000	-	-
1997	3,431	3,067,400,000	-	-
1998	2,587	2,833,276,000	-	-

- Not applicable
[a] Other fuel aviation gasoline.
[b] Other fuel motor gasoline.
[c] Construction Equipment includes snowmobiles. Other fuel is motor gasoline.
[d] Other fuel is motor gasoline.

Table C-5: Control Technology Assignments for Gasoline Passenger Cars (Percent of VMT)*

Model Years	Non-catalyst	Oxidation	Tier 0	Tier 1
1973-1974	100%			
1975	20%	80%		
1976-1977	15%	85%		
1978-1979	10%	90%		
1980	5%	88%	7%	
1981		15%	85%	
1982		14%	86%	
1983		12%	88%	
1984-1993			100%	
1994			60%	40%
1995			20%	80%
1996-1998				100%

* Excluding California VMT

Table C-6: Control Technology Assignments for Gasoline Light-Duty Trucks (Percent of VMT)*

Model Years	Non-catalyst	Oxidation	Tier 0	Tier 1
1973-1974	100%			
1975	30%	70%		
1976	20%	80%		
1977-1978	25%	75%		
1979-1980	20%	80%		
1981		95%	5%	
1982		90%	10%	
1983		80%	20%	
1984		70%	30%	
1985		60%	40%	
1986		50%	50%	
1987-1993		5%	95%	
1994			60%	40%
1995			20%	80%
1996-1998				100%

* Excluding California VMT

Table C-7: Control Technology Assignments for California Gasoline Passenger Cars and Light-Duty Trucks (Percent of VMT)

Model Years	Non-catalyst	Oxidation	Tier 0	Tier 1	LEV
1973-1974	100%				
1975-1979		100%			
1980-1981		15%	85%		
1982		14%	86%		
1983		12%	88%		
1984-1991			100%		
1992			60%	40%	
1993			20%	80%	
1994				90%	10%
1995				85%	15%
1996-1998				80%	20%

Table C-8: Control Technology Assignments for Gasoline Heavy-Duty Vehicles (Percent of VMT)

Model Years	Uncontrolled	Non-catalyst	Oxidation	Tier 0
≤1981	100%			
1982-1984	95%		5%	
1985-1986		95%	5%	
1987		70%	15%	15%
1988-1989		60%	25%	15%
1990-1998		45%	30%	25%

Table C-9: Control Technology Assignments for Diesel Highway VMT

Vehicle Type/Control Technology	Model Years
Diesel Passenger Cars and Light-Duty Trucks	
Uncontrolled	1966-1982
Moderate control	1983-1995
Advanced control	1996-1998
Heavy-Duty Diesel Vehicles	
Uncontrolled	1966-1972
Moderate control	1983-1995

Advanced control	1996-1998
Motorcycles	
Uncontrolled	1966-1995
Non-catalyst controls	1996-1998

Table C-10: Emission Factors (g/km) for CH_4 and N_2O and "Fuel Economy" (g CO_2/km)[c] for Highway Mobile Combustion

Vehicle Type/Control Technology	N_2O	CH_4	g CO_2/km
Gasoline Passenger Cars			
Low Emission Vehicles[a]	0.0176	0.025	280
Tier 1	0.0288	0.030	285
Tier 0	0.0507	0.040	298
Oxidation Catalyst	0.0322	0.070	383
Non-Catalyst	0.0103	0.120	531
Uncontrolled	0.0103	0.135	506
Gasoline Light-Duty Trucks			
Low Emission Vehicles[a]	0.0249	0.030	396
Tier 1	0.0400	0.035	396
Tier 0	0.0846	0.070	498
Oxidation Catalyst	0.0418	0.090	498
Non-Catalyst	0.0117	0.140	601
Uncontrolled	0.0118	0.135	579
Gasoline Heavy-Duty Vehicles			
Tier 0	0.1729	0.075	1,017
Oxidation Catalyst[b]	0.0870	0.090	1,036
Non-Catalyst Control	0.0256	0.125	1,320
Uncontrolled	0.0269	0.270	1,320
Diesel Passenger Cars			
Advanced	0.0100	0.01	237
Moderate	0.0100	0.01	248
Uncontrolled	0.0100	0.01	319
Diesel Light Trucks			
Advanced	0.0200	0.01	330
Moderate	0.0200	0.01	331
Uncontrolled	0.0200	0.01	415
Diesel Heavy-Duty Vehicles			
Advanced	0.0300	0.04	987
Moderate	0.0300	0.05	1,011
Uncontrolled	0.0300	0.06	1,097
Motorcycles			
Non-Catalyst Control	0.0042	0.13	219
Uncontrolled	0.0054	0.26	266

[a] Applied to California VMT only.
[b] Methane emission factor assumed based on light-duty trucks oxidation catalyst value.
[c] The carbon emission factor (g CO_2/km) was used as a proxy for fuel economy because of the greater number of significant figures compared to the km/L values presented in (IPCC/UNEP/OECD/IEA 1997).

Table C-11: Emission Factors for CH_4 and N_2O Emissions from Non-Highway Mobile Combustion (g/kg Fuel)

Vehicle Type/Fuel Type	N_2O	CH_4
Ships and Boats		
Residual	0.08	0.23
Distillate	0.08	0.23
Gasoline	0.08	0.23
Locomotives		

Residual	0.08	0.25
Diesel	0.08	0.25
Coal	0.08	0.25
Farm Equipment		
Gas/Tractor	0.08	0.45
Other Gas	0.08	0.45
Diesel/Tractor	0.08	0.45
Other Diesel	0.08	0.45
Construction		
Gas Construction	0.08	0.18
Diesel Construction	0.08	0.18
Other Non-Highway		
Gas Snowmobile	0.08	0.18
Gas Small Utility	0.08	0.18
Gas HD Utility	0.08	0.18
Diesel HD Utility	0.08	0.18
Aircraft		
Jet Fuel	0.1	0.087
Aviation Gasoline	0.04	2.64

Table C-12: NO_x Emissions from Mobile Combustion, 1990-1998 (Gg)

Fuel Type/Vehicle Type	1990	1991	1992	1993	1994	1995	1996	1997	1998
Gasoline Highway	**4,356**	**4,654**	**4,788**	**4,913**	**5,063**	**4,804**	**4,770**	**4,733**	**NA**
Passenger Cars	2,910	3,133	3,268	3,327	3,230	3,112	2,691	2,647	NA
Light-Duty Trucks	1,140	1,215	1,230	1,289	1,503	1,378	1,769	1,774	NA
Heavy-Duty Vehicles	296	296	280	286	318	301	298	301	NA
Motorcycles	11	10	11	11	11	12	11	11	NA
Diesel Highway	**2,031**	**2,035**	**1,962**	**1,900**	**1,897**	**1,839**	**1,803**	**1,787**	**NA**
Passenger Cars	35	34	35	36	35	35	31	31	NA
Light-Duty Trucks	6	7	7	7	9	9	11	11	NA
Heavy-Duty Vehicles	1,989	1,995	1,920	1,857	1,854	1,795	1,760	1,745	NA
Non-Highway	**4,357**	**4,443**	**4,474**	**4,482**	**4,548**	**4,651**	**4,688**	**4,770**	**NA**
Ships and Boats	906	953	924	884	896	903	951	962	NA
Locomotives	843	842	858	857	859	898	836	870	NA
Farm Equipment	819	837	854	870	886	901	913	915	NA
Construction Equipment	1,003	1,020	1,036	1,052	1,069	1,090	1,109	1,119	NA
Aircraft[a]	143	141	142	142	146	150	151	151	NA
Other[b]	642	650	661	676	692	709	727	754	NA
Total	**10,744**	**11,132**	**11,224**	**11,294**	**11,508**	**11,294**	**11,261**	**11,289**	**NA**

[a] Aircraft estimates include only emissions related to LTO cycles, and therefore do not include cruise altitude emissions.
[b] "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.
Note: Totals may not sum due to independent rounding.

Table C-13: CO Emissions from Mobile Combustion, 1990-1998 (Gg)

Fuel Type/Vehicle Type	1990	1991	1992	1993	1994	1995	1996	1997	1998
Gasoline Highway	**51,332**	**55,104**	**53,077**	**53,375**	**54,778**	**47,767**	**46,965**	**45,477**	**NA**
Passenger Cars	33,746	36,369	35,554	35,357	33,850	30,391	25,894	24,998	NA
Light-Duty Trucks	12,534	13,621	13,215	13,786	15,739	13,453	17,483	17,186	NA
Heavy-Duty Vehicles	4,863	4,953	4,145	4,061	5,013	3,741	3,416	3,123	NA
Motorcycles	190	161	163	172	177	182	171	170	NA
Diesel Highway	**1,147**	**1,210**	**1,227**	**1,240**	**1,316**	**1,318**	**1,354**	**1,394**	**NA**
Passenger Cars	28	27	28	30	29	30	27	27	NA
Light-Duty Trucks	5	5	6	6	7	7	10	10	NA

Heavy-Duty Vehicles	1,115	1,177	1,193	1,205	1,280	1,281	1,318	1,358	NA
Non-Highway	**16,506**	**16,863**	**17,239**	**17,595**	**17,962**	**18,347**	**18,354**	**18,430**	**NA**
Ships and Boats	2,040	2,053	2,054	2,053	2,059	2,064	2,069	2,082	NA
Locomotives	110	109	113	108	104	103	102	106	NA
Farm Equipment	527	537	547	557	566	575	582	581	NA
Construction Equipment	1,148	1,171	1,194	1,216	1,238	1,258	1,249	1,220	NA
Aircraft[a]	820	806	818	821	830	855	861	859	NA
Other[b]	11,860	12,187	12,514	12,840	13,165	13,492	13,492	13,582	NA
Total	**68,985**	**73,177**	**71,543**	**72,210**	**74,057**	**67,433**	**66,674**	**65,301**	**NA**

[a] Aircraft estimates include only emissions related to LTO cycles, and therefore do not include cruise altitude emissions.
[b] "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.
Note: Totals may not sum due to independent rounding.

Table C-14: NMVOCs Emissions from Mobile Combustion, 1990-1998 (Gg)

Fuel Type/Vehicle Type	1990	1991	1992	1993	1994	1995	1996	1997	1998
Gasoline Highway	**5,444**	**5,607**	**5,220**	**5,248**	**5,507**	**4,883**	**4,743**	**4,614**	**NA**
Passenger Cars	3,524	3,658	3,447	3,427	3,367	3,071	2,576	2,504	NA
Light-Duty Trucks	1,471	1,531	1,440	1,494	1,731	1,478	1,869	1,830	NA
Heavy-Duty Vehicles	392	384	303	296	375	297	266	247	NA
Motorcycles	56	33	30	31	33	37	33	32	NA
Diesel Highway	**283**	**290**	**288**	**288**	**300**	**290**	**238**	**221**	**NA**
Passenger Cars	11	11	12	12	12	12	11	11	NA
Light-Duty Trucks	2	3	3	3	4	4	5	5	NA
Heavy-Duty Vehicles	269	276	274	273	284	274	223	206	NA
Non-Highway	**2,310**	**2,342**	**2,354**	**2,382**	**2,416**	**2,449**	**2,417**	**2,334**	**NA**
Ships and Boats	743	747	729	731	738	738	738	742	NA
Locomotives	48	47	49	47	45	45	44	46	NA
Farm Equipment	133	133	132	132	131	130	129	124	NA
Construction Equipment	204	208	212	216	220	225	223	216	NA
Aircraft[a]	163	161	162	160	159	161	161	160	NA
Other[b]	1,019	1,046	1,070	1,096	1,123	1,150	1,122	1,046	NA
Total	**8,037**	**8,239**	**7,862**	**7,919**	**8,223**	**7,621**	**7,398**	**7,169**	**NA**

[a] Aircraft estimates include only emissions related to LTO cycles, and therefore do not include cruise altitude emissions.
[b] "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.
Note: Totals may not sum due to independent rounding.